TOWARDS AN INTEGRATED MULTI-WAVELENGTH APPROACH TO PLANETARY SURFACE COMPOSITIONS.

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Introduction: Global knowledge of surface compositions are the basis for our understanding of formation and evolution of planets. For most of such data we rely on remote sensing observations. *In-situ* measurements, returned samples and meteorites for the Moon and Mars provide higher level accuracies and have indeed resulted in major insights, which cannot be achieved by remote sensing. In spite of this, even in the case of the Moon, remote sensing measurements are important and continue to improve our understanding of the Moon. For example, the samples collected are from specific regions, which need not be representative of the whole lunar surface. This is evident from several recent orbital investigations that have yielded surprises [1],[2],[3]. At this juncture it is imperative that for future missions we seek newer and different approaches with the objective of building upon the existing wealth of data.

Remote sensing on planetary missions typically have used the NIR region, X ray and gamma ray spectroscopy in the past. More recently UV and thermal IR on the Moon has also been used for mapping compositions. It is rather clear that multi-wavelength observations that probe different aspects of composition would be a useful approach to confirm results and do away with ambiguities.

Often the results from separate investigations when compared do not give identical numbers. For example, elemental abundances can be derived from NIR spectral parameters using assumptions on the mineralogy and petrology as well as more directly from X-ray and gamma ray spectrometers. The differences observed can arise from the difference in spatial scales, assumptions in estimating abundances, limitations in the algorithms, inherent sensitivity of the wavelength region to certain features and such factors. We propose to develop methods for an integrated analysis approach right from the point of spectral data analysis incorporating the information from different wavelength regions in an iterative manner.

Samples and Methods: Terrestrial anorthosites (gabbroic anorthosites) of varying grain sizes (30-80 µm, 80-150 µm, 150-300 µm, 300-500 µm, 600 – 1000 µm) and two terrestrial basalt (Low-Ti and high-Ti) samples are studied for its X-Ray and UV-MIR reflectance spectroscopy. The chemical composition of the samples derived from XRF is tabulated in Table 1. In this study we aim to develop an integrated spectroscopy approach by carefully undertaking the comparative spectroscopic investigation of the XRF and optical reflectance spectra of these terrestrial samples.

Planetary Spectroscopy Laboratory: The reflectance spectroscopy of the samples in wide spectral range covering from ultraviolet (UV) to mid-infrared (MIR) spectral regions (0.2µm – 25µm) is carried out at Planetary Spectroscopy Laboratory (PSL) facility located at Department of Planetary Laboratories of the Institute for Planetary Research (PF) at the German Aerospace Center (DLR), Berlin [4]. Two Bruker Vertex 80V spectrometers fitted with Bruker A513 variable-angle reflection accessory are used for the reflectance measurements at the incidence angle 30° and emittance angle of 0° (phase angle of 30°) under vacuum conditions. Figures 1 and 2 show sample spectra in the entire band for powdered anorthosites and basalts respectively. UV-MIR spectra of varying grain sizes of terrestrial anorthosites (Fig. 1) show that the smaller grain sizes display brighter spectra at all wavelengths.

XRF measurements: X-ray fluorescence measurements are being done at the U R Rao Satellite Centre in a vacuum chamber at fixed angles using an X-ray continuum source (AMPTEK X-ray tube) and Si-PIN detector. Preliminary results for the anorthositic sample show (Fig. 3) show the reduction in XRF line flux with increase in grain size.

Table 1. Shows the wt% of chemical composition of the samples studied.

sample	Si	Ti	Al	Fe	Mg	Ca	Na	O
Anorthosite	22	0.0	16.2	0.0	1.8	12	1.1	45.5
Basalt -1	25	1.9	7.2	10.9	2.7	5.8	2.1	45.5
Basalt-2	22.8	2.2	7.3	11.3	3.1	6.7	2.0	44.3

On-going work and conclusions: The relationship between the spectral parameters derived from reflectance spectra and its corresponding XRF spectra is being studied for the newer approach of integrated spectroscopic approach. We envisage applying the results of these studies to CLASS [5] and IIRS [6] instruments on the Chandrayaan-2 orbiter.

References: [1] Sun Y. et al. (2017) *EPSL,* 465, 48-58. [2] Yamamoto S et al. (2012) *GRL*, 39, L13201. [3] Athiray P.S et al. (2014) *PSS,* 104, 279-287. [4] Maturilli A. et al. (2019) 50th LPSC meeting. [5] Narendranath S et al. at this meeting #1186. [6] Battacharya S et al. at this meeting.

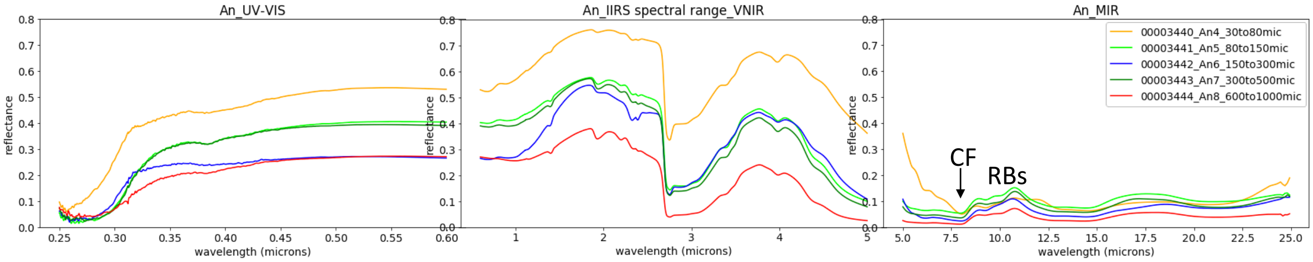

Figure 1. UV-MIR spectrum of anorthosite samples of varying grain sizes at phase angle 30° under vacuum.

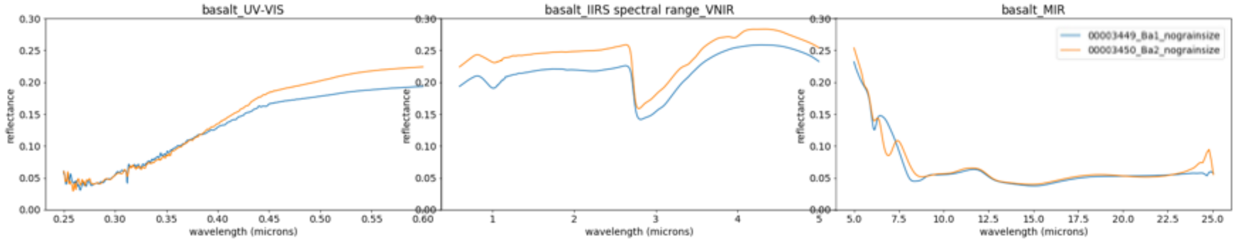

Figure 2. UV-MIR spectrum of two basalt samples at phase angle 30° under vacuum.

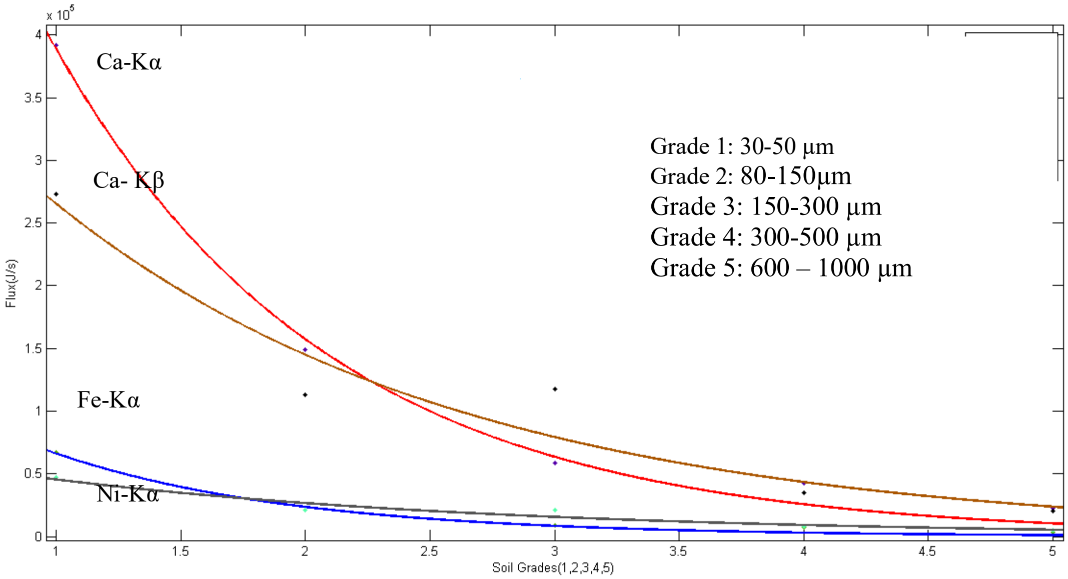

Figure 3: Change in XRF line flux with grain size